

**University of Dundee**

## **Melting Glaciers Annual Newsletter 2019**

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## Yfirlit um íslenska jökla í árslok 2019

Jöklar á Íslandi hafa hopað hratt í um aldarfjórðung og er rýrnun þeirra einhver helsta afleiðing og skýrasti vitnisburður hlýnandi loftslags hárlands. Hér er gerð stutt grein fyrir breytingum á jöklunum síðan um aldamótin 1900 og lýst niðurstöðum mælinga á stöðu jökulsporða, afkomu jökla og landlyftingu á síðustu árum. Birt eru uppfærð kort af legu jökulsporða haustið 2019 og uppfærðar teikningar af afkomu jökla með mælingum ársins 2019.

## Overview of Icelandic glaciers at the end of 2019

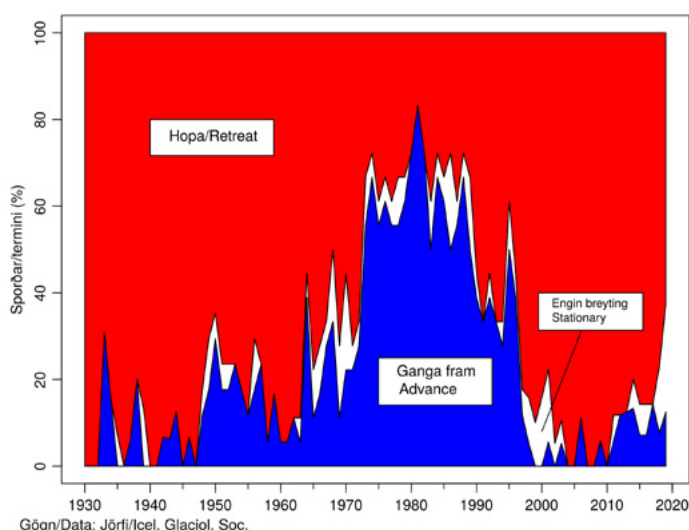
Glaciers in Iceland have retreated rapidly for a quarter of a century, and glacier downwasting is one of the most obvious consequences of a warming climate in the country. In this newsletter, glacier changes since about 1900 are described briefly along with the results of monitoring of glacier termini, glacier mass balance and crustal movements induced by glacier changes in recent years. Updated maps of glacier outlines in the fall of 2019 and updated mass balance time series are presented.

### JÖKLABREYTINGAR

Flatarmál íslenskra jökla hefur minnkað um u.þ.b. 800 km<sup>2</sup> síðan árið 2000 og tæplega 2200 km<sup>2</sup> frá lokum 19. aldar þegar jöklarnir náðu mestu útbreiðslu síðan land byggðist. Síðustu árin hefur heildarflatarmál jökla minnkað um u.þ.b. 40 km<sup>2</sup> árlega að meðaltali. Á árinu 2019 hopuðu jökulsporðar víða um tugi metra. Af þeim jöklum sem mældir eru af sjálfboðaliðum Jöklarannsóknafélags Íslands hopuðu Hagafellsjökull eystri í Langjökli og Síðujökull og Tungnárjökull í Vatnajökli mest, eða um 150 m. Hraðast hörfar Breiðamerkurjökull þar sem kelfir af honum í Jökulsárlón, milli 150 og 400 m árið 2019.

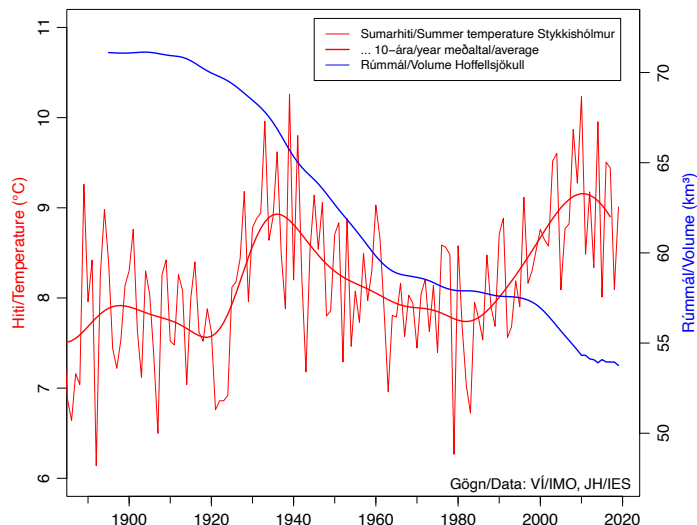
### GLACIER CHANGES

Since 2000, the area of Iceland's glaciers has decreased by ca. 800 km<sup>2</sup>, and by almost 2200 km<sup>2</sup> since the end of the 19th century when the glaciers reached their maximum extent since the country's settlement in the 9th century CE. The glacier area has on average shrunk by ca. 40 km<sup>2</sup> annually in recent years. Glaciers typically retreated by tens of metres in 2019. Hagafellsjökull eystri in Langjökull ice cap and Síðujökull and Tungnárjökull in Vatnajökull ice cap hold the 2019 record in the terminus variations dataset of the Iceland Glaciological Society, retreating by 150 m in this single year. The Breiðamerkurjökull outlet glacier of the Vatnajökull ice cap retreats even faster, where it calves into Jökulsárlón lagoon. The retreat of the calving front measured 150–400 m in 2019.



Árlegt hlutfall íslenskra jökla sem gengu fram eða hopuðu á árunum 1931–2019. Framhlaupsjökla eru ekki taldir með. Myndin sýnir gögn frá 10–20 jökulsporðum fyrir flest ár.

The annual proportion of monitored non-surging Icelandic glacier termini that advanced or retreated in the period 1931–2019. The figure is based on data from 10–20 glaciers for most years.

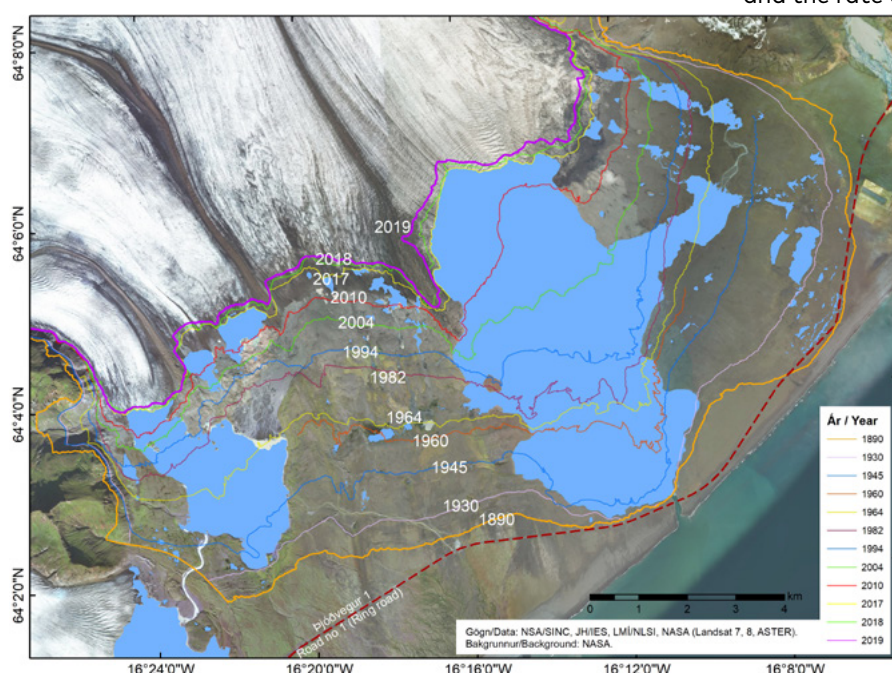


Síðan um aldamótin 1900 hafa skipt á köld og hlý tímabil í veðurfari á Íslandi eins og sjá má á sumarihitinu í Stykkishólmi. Jöklar hafa minnkað hraðast á hlýjum tímaseiðum sbr. breytingar í rúmmáli Hoffellsjökuls á tímabilinu.

The climate of Iceland since 1900 has been characterized by decades-long cool and warm periods, cf. the summer temperature in Stykkishólmur W-Iceland. Glaciers have lost mass most rapidly during warm periods as seen for Hoffellsjökull, SE-Iceland.

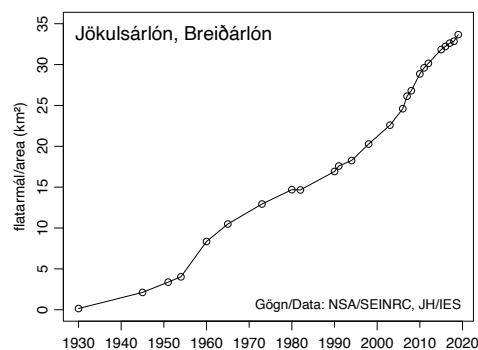
## JÖKULSÁRLÓN Á BREIÐAMERKURSANDI

Við Jökulsárlón má sjá hversu mikil áhrif kelfing í sjó fram og í jökullón hefur á afkomu jökla. Jökulsárlón byrjaði að myndast um 1935. Það er nú ásamt Breiðárlóni og nokkrum öðrum minni lónum við jaðar Breiðamerkurjökuls yfir 30 km<sup>2</sup> að flatarmáli. Síðustu árin hafa lónin samtals stækkað um 0.5–1 km<sup>2</sup> árlega að meðaltali. Breiðamerkurjökull hörfar og þynnist bæði vegna yfirborðsleysingar í hlýnandi loftslagi og kelfingar (ís brotnar af sporðinum út í vatn eða sjó) í Jökulsárlón. Um þriðjungur massataps Breiðamerkurjökuls síðustu ár er vegna kelfingar. Hinar stóru ísbreiður Suður-skautlandsins og Grænlands tapa miklum ís við kelfingu og hefur hraði kelfingarinnar þar aukist að miklum mun á síðustu árum.



## THE JÖKULSÁRLÓN GLACIER LAGOON

The Jökulsárlón glacier lagoon demonstrates how important calving into the ocean or terminal lakes can be for the mass balance of glaciers. Jökulsárlón lagoon started to form in the mid-1930s because of the retreat of the glacier. The lagoons by the terminus of Breiðamerkurjökull, Jökulsárlón and Breiðárlón, as well as some smaller lagoons, now have a combined area of over 30 km<sup>2</sup>. On average, the lagoons have grown by 0.5–1 km<sup>2</sup> annually in recent years. The Breiðamerkurjökull glacier retreats and thins due to negative surface mass balance in a warming climate but also due to calving (ice breaks off the front into lakes or sea) into Jökulsárlón lagoon. Calving currently causes about 1/3 of the mass loss of Breiðamerkurjökull. The large ice sheets of Antarctica and Greenland lose large amounts of ice by calving, and the rate of loss has intensified greatly in recent years.

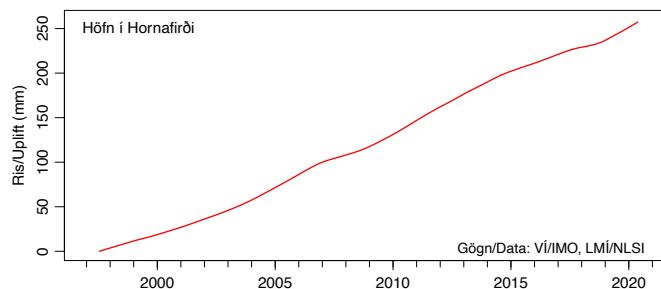


Breytingar á jaðri Breiðamerkurjökuls (t.v.) og heildarflatarmál lóna við jökuljaðarinn (að ofan) á mismunandi tímum frá lokum 19. aldar.

Changes in the ice margin of Breiðamerkurjökull outlet glacier by Jökulsárlón lagoon (left) and the total area of lakes by the ice margin (above) since the end of the 19th century.

## JARÐSKORPUHREYFINGAR

Massatap jöklanna veldur hröðu landrís vegna þess hve seigja möttulefnisins undir Íslandi er lítil. Við Höfn í Horna-firði er landrís nú um 10–15 mm á ári og hefur hraði þess tekið talsverðum breytingum á undanförunum tveimur ára-tugum vegna breytileika í afkomu jökulsins. Land rís enn hraðar við vesturjaðar Vatnajökuls þar sem rishraðinn mælist allt að 40 mm á ári.

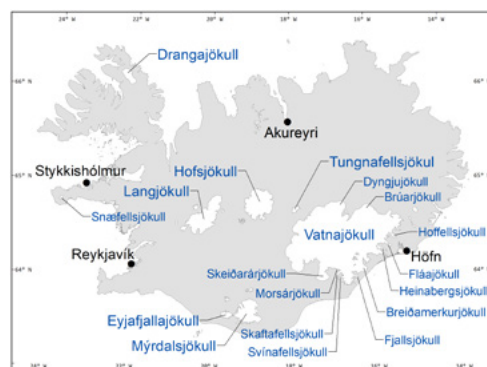


Landhæðarbreytingar á Höfn í Hornafirði frá 1997 til vors 2020 skv. GPS-mælingum. Kortið til hægri sýnir helstu jökla landsins.

Crustal uplift measured by GPS at Höfn in Hornafjörður in SE-Iceland. The location map shows the main glaciers of Iceland as well as the location of Höfn in Hornafjörður.

## CRUSTAL MOVEMENTS

Rapid melting of glaciers leads to crustal uplift near the ice margins because of the low viscosity of the mantle under Iceland. The land at Höfn in Hornafjörður in SE-Iceland currently rises by ca. 10–15 mm per year and the rate of uplift has varied substantially over the last two decades due to variations in the rate of mass loss of the glacier. The rate of uplift is even larger near the western margin of Vatnajökull where it has been measured at ca. 40 mm per year.



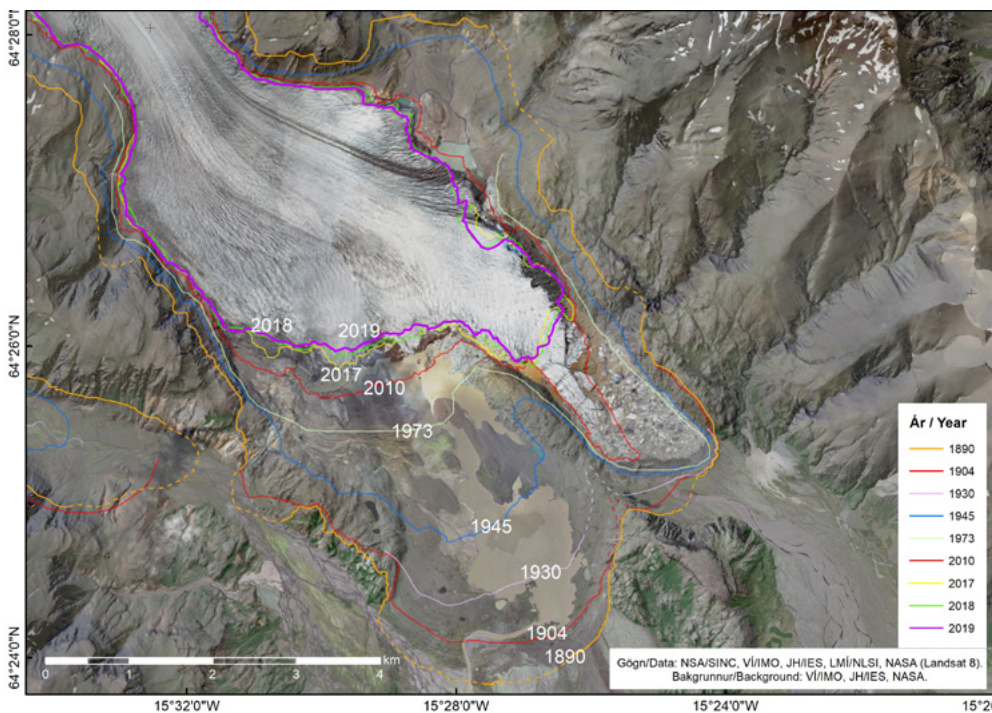


## HOFFELLSJÖKULL

Hoffellsjökull í Hornafirði hefur rýrnað mikið síðan hann náði hámarksútbreiðslu undir lok 19. aldar og býður umhverfi jökulsins upp á einstætt tækifæri til þess að skoða ummerki jökuhröfnunar frá hámarki litlu ísaldar. Hörfun jökulsins hefur leitt til myndunar löns við sporðinn sem hefur stækkað hratt síðan um aldamótin 2000. Flatarmál Hoffellsjökuls hefur minnkað um tæplega 40 km<sup>2</sup> síðan um aldamótin 1900 og um rúmlega 0,5 km<sup>2</sup> á ári að meðaltali síðustu árin.

## THE HOFFELLSJÖKULL OUTLET GLACIER

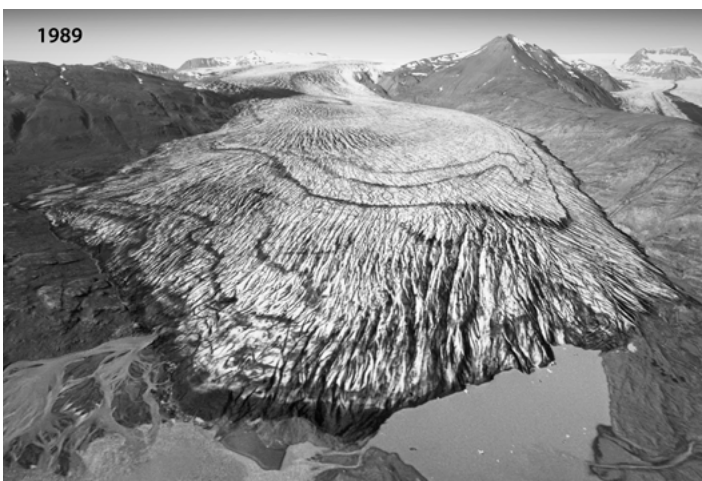
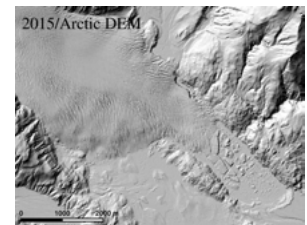
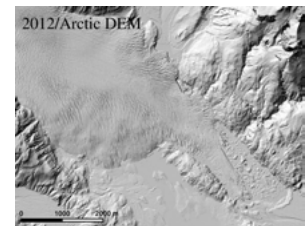
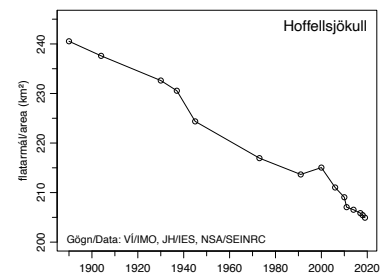
The Hoffellsjökull outlet glacier has retreated and thinned greatly since the end of the 19th century, when the glacier reached its maximum extent in recent times. The foreland of Hoffellsjökull provides unique opportunities to observe the geomorphological effects of glacier retreat. The retreat of the glacier has led to the formation of a terminus lake that has grown rapidly since the turn of the 21st century. The area of Hoffellsjökull has decreased by ca. 40 km<sup>2</sup> since the end of the 19th century and by more than 0.5 km<sup>2</sup> annually in recent years.



Hörfun Hoffellsjökuls frá lokum 19. aldar. Kortið sýnir stöðu jaðarsins á mismunandi tímum og línuritið uppi t.h. rýrnandi flatarmál jökulsins. Skyggð landlíkön af jökultungunni frá 2012 og 2015 sem byggð eru á gervihnattamælingum eru sýnd til hægri.

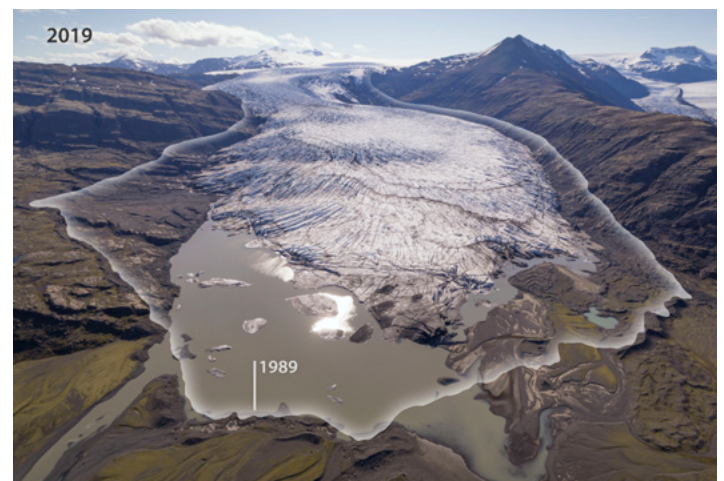
The retreat of Hoffellsjökull outlet glacier since the end of the 19th century. The map shows the glacier margin at different points in time and the graph at the upper right shows the diminishing area of the glacier. The shadings to the right are computed from digital terrain models of

the glacier tongue from 2012 and 2015 derived from satellite images.



Flugsýn af tungu Skálafellsjökuls 1989 og 2019. Myndirnar byggja á ljósmyndum sem teknar voru úr flugvél 1989 og flygildi 2019 og landlíkönun sem reiknuð voru á

grundvelli myndanna og sýna vel lækun yfirborðs jökulsins á 30 ára tímabili.

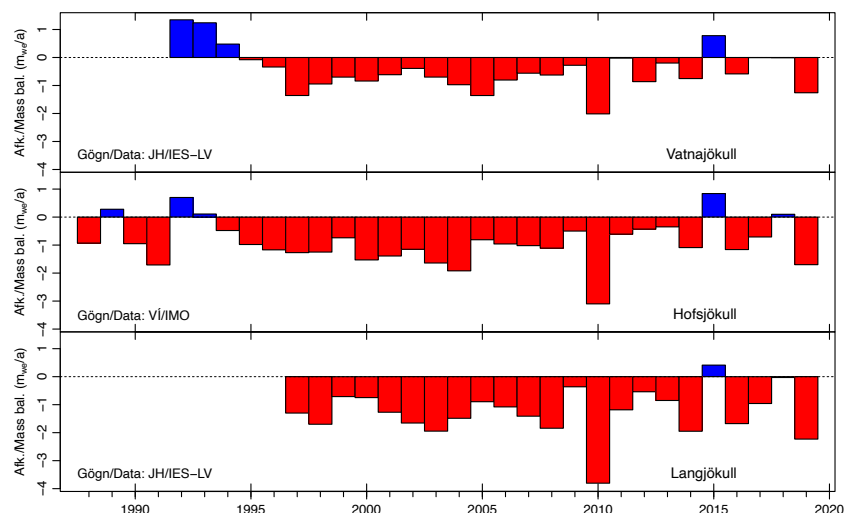


Bird's-eye views of the tongue of Skálafellsjökull in 1989 and 2019. The views are produced from aerial photographs taken from an aircraft in 1989 and an unmanned

aerial vehicle in 2019 and show well the lowering of the glacier surface over the 30-year period.

## AFKOMA

Afkoma stærstu íslensku jöklanna hefur verið neikvæð síðan 1995 með einni undantekningu, afkoma ársins 2015 var jákvæð í fyrsta sinn í 20 ár. Árið 2016 mældist afkoman aftur neikvæð eins og flest undanfarin ár og einnig fyrir Langjökul og Hofsjökul árið 2017 en Vatnajökull var þá nærri því að vera í jafnvægi. Allir þrír jöklarnir voru nærri jafnvægi 2018. Sumarið 2019 var mjög hlýtt og mældist afkoma allra þriggja jöklanna þá neikvæð. Jöklarnir hafa alls tapað um 250 km<sup>3</sup> íss síðan 1995 sem er um 7% af heildarrúmmáli þeirra.

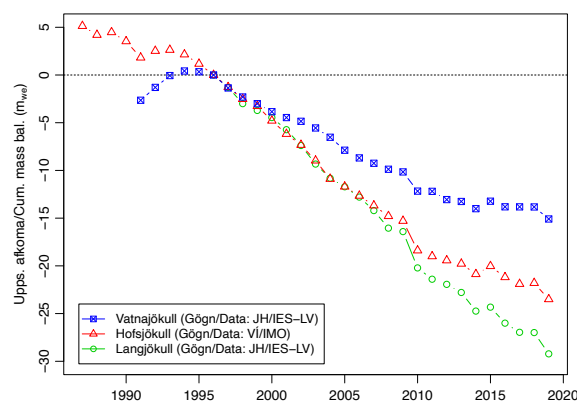


Árleg og uppsöfnuð afkoma Vatnajökuls, Hofsjökuls og Langjökuls frá upphafi mælinga á hverjum jökli samkvæmt gögnum Jarðvísindastofnunar Háskólans,

Landsvirkjunar og Veðurstofu Íslands. Þessir jöklar geyma yfir 95% af rúmmáli íss í jöklum landsins.

## GLACIER MASS BALANCE

The mass balance of the largest Icelandic glaciers has been negative since 1995, with the exception of the year 2015 when it became positive for the first time in 20 years. The mass balance in 2016 was again negative by a magnitude similar to that in previous years. The mass balance of Langjökull and Hofsjökull was again negative in 2017, whereas Vatnajökull was almost in balance. All three ice caps were near balance in 2018. The summer of 2019 was quite warm and the mass balance of all three ice caps was negative. The glaciers have lost ca. 250 km<sup>3</sup> of ice since 1995, which corresponds to ca. 7% of their total volume.



Annual and accumulated mass balance of Vatnajökull, Hofsjökull and Langjökull ice caps since the start of regular mass-balance measurements on each glacier.

These three ice caps contain >95% of the volume of ice in the glaciers of Iceland.

## AFKOMA JÖKLANNA MJÖG NEIKVÆÐ ÁRIÐ 2019

Samhliða hlýnun loftslags á Íslandi frá miðjum tíunda áratug síðustu aldar rýrnuðu jöklar hratt, að jafnaði um u.þ.b. 1 m vatns á ári að meðaltali á tímabilinu 1997–2010. Eftir 2010 hafa komið köld og blaut sumur inn á milli, þannig að meðal-rýrnun árána 2011–2018 var ekki nema þriðjungur til helmingur þess sem verið hafði í rúman áratug þar á undan. Sumarið 2019 var víðast hlýtt og sólrikt enda rýrnuðu jöklar þá um u.þ.b. 1,5 m vatns sem er með því mesta sem mælst hefur. Nánar má fræðast um samband jökla og loftslags á fræðsluvef Vatnajökulspjóðgarðs um jökla- og loftslagsbreytingar Hörfandi jökla: [www.vjp.is/is/svaedin/horfandi-joklar](http://www.vjp.is/is/svaedin/horfandi-joklar).

MASS BALANCE OF THE ICELANDIC GLACIERS  
NEGATIVE IN 2019

Glaciers in Iceland retreated rapidly after the mid-1990s as a consequence of warming climate. The mass loss was ca. 1 m water per year on average in the period 1997–2010. After 2010, some summers have been cool and wet and this is reflected in the glacier mass loss, which in the period 2011–2018 was on average only one-third to one-half of the average of the preceding one or two decades. The summer of 2019 was warm and sunny. Consequently, the glacier ablation increased substantially and the mass loss was measured as ca. 1.5 m water per year which is among the highest values on record. Further information about the relationship between glaciers and climate may be found on the educational website of the Vatnajökull National Park Melting glaciers: [www.vjp.is/en/areas/melting-glaciers](http://www.vjp.is/en/areas/melting-glaciers).



HÁSKÓLI ÍSLANDS  
JARÐVÍSINDASTOFNUN



Upplýsingarnar sem hér birtast eru byggðar á mælingum jöklahóps Jarðvísindastofnunar Háskólans (JH), Veðurstofu Íslands (VI), Landsvirkjunar (LV), Náttúrufestu Suðausturlands (NSA) og Jöklarannsóknafélags Íslands (Jörfi). Nánari upplýsingar um sporðamælingar veitir Hrafnhildur Hannesdóttir ([hh@vedur.is](mailto:hh@vedur.is)), um afkomumælingar Finnur Pálsson ([fp@hi.is](mailto:fp@hi.is)) og Þorsteinn Þorsteinsson ([thor@vedur.is](mailto:thor@vedur.is)), um jarðskorpuphreyfingar Benedikt G. Ófeigsson ([bgo@vedur.is](mailto:bgo@vedur.is)) og um mælingar á hörfun Breiðamerkur- og Hoffellsjökli Snævarr Guðmundsson ([snavearr@natts.is](mailto:snavearr@natts.is)). Kieran Baxter útbjó flugsýn af Hoffellsjökli.

The results presented here are based on the measurements of the glacier group of the The Institute of Earth Sciences, University of Iceland (IES), the Icelandic Meteorological Office (IMO), Landsvirkjun – the National Power Company of Iceland (LV), the South East Iceland Nature Research Center (SEINRC) and the Iceland Glaciological Society (Jörfi). Further information about terminus variations is provided by Hrafnhildur Hannesdóttir ([hh@vedur.is](mailto:hh@vedur.is)), about mass balance by Finnur Pálsson ([fp@hi.is](mailto:fp@hi.is)) and Þorsteinn Þorsteinsson ([thor@vedur.is](mailto:thor@vedur.is)), about crustal movements by Benedikt G. Ófeigsson ([bgo@vedur.is](mailto:bgo@vedur.is)) and about the Breiðamerkur- og Hoffellsjökull glaciers by Snævarr Guðmundsson ([snavearr@natts.is](mailto:snavearr@natts.is)). Kieran Baxter produced the bird's-eye views of Heinabergsjökull.



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